

Physics

THE PINHOLE TELESCOPE: ARE THE TEXTBOOKS WRONG ABOUT PROJECTED VIRTUAL IMAGES?

Kimberly A. Kirchner and Dale W. Olson*

University of Northern Iowa

205 Physics Building

Cedar Falls, Iowa 50614-0150

Physics@uni.edu

It is commonly stated in physics textbooks that real images can be projected onto a screen whereas virtual images cannot. We believe this statement is incorrect. We have explored whether a pinhole camera model can correctly describe the projected light images emanating from the eyepiece of a refracting telescope. In this model the exit pupil of the telescope acts like a pinhole, and the virtual image formed by the eyepiece becomes the object whose image is projected through the exit pupil/pinhole. In the model, and experimentally, smaller exit pupil diameters can produce sharper images for a fixed screen distance. Using a constructed two-lens refracting telescope we image a 15 mm square air force resolution target placed 520 cm from the telescope. Virtual image light leaving the telescope eyepiece is projected onto a screen, and the image is photographed. Also, in a related experiment, to further demonstrate virtual image projectability, projected light patterns formed by a transmission hologram were viewed. The model permits us to design a three stage (Lens 1, Lens 2, Exit Pupil) pinhole telescope which forms an image twice as large (for example) as the original object, even though the object is at a distance of 5.20 meters, and which presents detail twice as well as that available if the object is located at the viewer's near point, and viewed with the unaided eye. For transmission hologram projected images, for a screen twenty centimeters behind the hologram successively smaller exit pupil diameters (laser viewing beams ranging in diameter from 1.5 mm up to 102 mm) produced successively sharper projected virtual images. We conclude that virtual images can be projected onto a screen. Our model predicts that, for a high quality eyepiece, the projected virtual image quality can be identical to that obtained in a more conventional manner, and better than what might be obtained using the unaided eye to view the object at the near point. A definitive test requires reduction of the aberrations in the telescope we are using to perform these experiments. This research was supported by the UNI Physics Department, and the UNI College of Natural Science.